Evaluation of methods to separate brown and water frogs

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ABSTRACT - Methods given in the herpetological literature for distinguishing between the northwest European brown and water frog groups (*Rana* and *Pelophylax* respectively) are reviewed and evaluated. Published guidance contains inaccuracies that could create misidentifications. The unreliability of the method most commonly described for separating the two groupings, the presence/absence of an eye stripe, is highlighted. The relative distance between the eyes and the degree to which eyes are upturned both reliably distinguish between the two groups. Differences in the shapes of dorsolateral folds also separate the two groups, but less unequivocally.

AN experienced herpetologist can distinguish between brown or water frogs on 'General Impression of Shape and Size' (GISS, occasionally written as 'gizz' or 'jizz'). It has, however, been the author's experience that a great deal of published guidance (including the most widely read) on the separation of these groups is inadequate or erroneous. This present work tests the accuracy of some of the published methods of separation and revises existing guidance.

The work focuses on northwest European species, comprising three indigenous brown frogs, the common frog *Rana temporaria*, the moor frog *Rana arvalis* and the agile frog *Rana dalmatina*, and three indigenous water frog types, comprising two species, the pool frog *Pelophylax lessonae* (formerly *Rana lessonae*) and the marsh frog *Pelophylax ridibundus* (formerly *Rana ridibunda*), and their hybrid, the edible frog *Pelophylax* kl. *esculentus* (formerly *Rana* kl. *esculenta*).

Colour is not always a reliable guide for separating the brown and water frogs. Water frogs often have areas of vivid green dorsally (hence the alternative name of green frogs). Although this colour intensity is not achieved in the brown frogs, some common frogs have a pale olive colouring dorsally. To compound the problem some pool and edible frogs can also be brown dorsally. In fact, the northern clade pool frog (the form native to Britain and Scandinavia) is always brown. The presence of a dorsal stripe for group or species separation is also unreliable and intraspecific variation occurs geographically. Juvenile and female pool and edible frogs often have a dorsal stripe as do many males. The occasional common frog and a great many moor frogs also have dorsal stripes (although these are often wider and less defined at the edges than those in the water frogs). In the marsh frog the striped condition seems to vary from population to population. In the southern Kent marshes and parts of the north Kent marshes, the author has not yet seen a striped marsh frog, while on Chetney Marshes in north Kent, striped individuals are common.

Behaviour can be a useful guide. Water frogs are usually found in, or close to, water (usually within 2 m). If they are on the banks when approached, they launch themselves into the water with surprisingly little splash. Brown frogs, such as the common frog, are mainly to be found in water only in very early spring (usually before the water frogs have even left hibernation) and are noisier and less streamlined in their entry into the water. They are also less nervous and can be more closely approached without causing them to panic.

The presence of paired vocal sacs (one either side of the head) in water frogs is a reliable guide but limited to males and, outside of the spring to early summer calling season, needs examination in the hand. Identification handbooks suggest various other ways of separating the two groups, which are summarised below.

Relative Distance Between the Eyes

Arnold & Ovenden (2002) describe the eyes of water frogs as 'close together' whereas those of brown frogs are 'well separated' (Fig. 1).

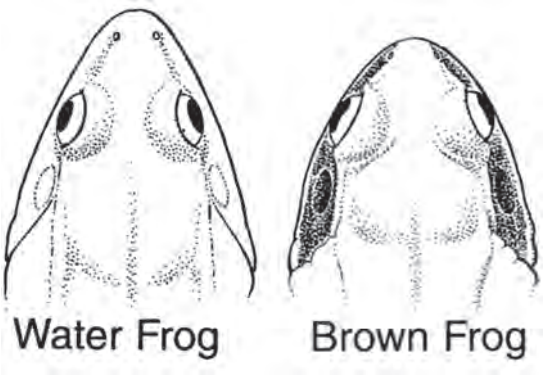

Figure 1. Illustration from Arnold & Ovenden (2002) depicting the difference in the relative separation of the eyes.

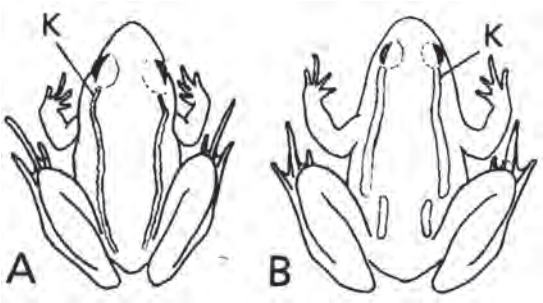

Figure 2. An Illustration from Fog et al. (1997) indicating differences in the form of the dorsolateral folds (K). A = typical brown frog, B = typical water frog.

Inclination of the Eyes

Nöllert & Nöllert (1992) suggest that the eyes of water frogs appear to be more upward looking than those of the brown frog group.

Configuration of the Dorsolateral Folds

Fog et al. (1997 [in Danish]) suggest that there is a difference between the groups in the linear patterns of the dorsolateral folds (Fig. 2).

Presence/Absence of a Temporal Mask

The most enduring and widespread advice in the literature concerns the presence (in brown frogs) or absence (in water frogs) of a dark 'facial mask'. This is also variously described as a temporal mask or facial stripe. This advice has been given for over a century as a reliable means of separating brown and water frogs and can be found in even the most popular and frequently cited European amphibian and reptile identification handbooks (Mivart, 1874; Chihar & Cepika, 1979; Laňka & Vít, 1989; Arnold, Burton & Ovenden, 1978; Beebee & Griffiths, 2000; Arnold & Ovenden, 2002; Wycherley, 2003; Inns, 2009). Nöllert & Nöllert (1992) suggested less certainty, stating that brown frogs mainly, and water frogs rarely, possess a mask. Other guides (Matz & Weber, 1983; Ballasina, 1984) do not mention this method. Morrison (1994) stated that a temporal mask was a characteristic of brown frogs, however, this text was embedded among illustrations of seven common frogs, three of which had no temporal mask. The ideal case inferred by the literature is shown in Fig. 1, which shows the head of a typical water frog with no temporal stripe and a brown frog with a bold stripe. The dark stripe begins at the tip of the snout, runs through the nostril and stops at the anterior part of the eye. It then continues from the posterior part of the eye and passes diagonally downwards across the eardrum and towards the shoulder.

MATERIALS AND METHODS

Relative Distance Between the Eyes

Photographs of 20 brown frogs and 20 water frogs were taken with a digital camera held directly over the subject's head. Measurements were made from enlarged photographs using a Vernier calliper. These included the width of the head *a* and the distance between the inner margins of the eyes *b*, both measured along a line taken through the centre of the eyes (Fig. 3). Distance *a* was divided by *b* to give the relative separation of the eyes in the two frog groups.

Inclination of the Eyes

To measure relative eye width visible from above (i.e. to test if the eyes of water frogs are more upward looking than those of brown frogs), the distance between the outer edges of the eyes *c* was measured (Fig. 3). The difference between *c* and *b* was divided by *a* ([*c*-*b*]/*a*). To test if the species were comparable in respect of head width (measured just behind the eye bulge), body length

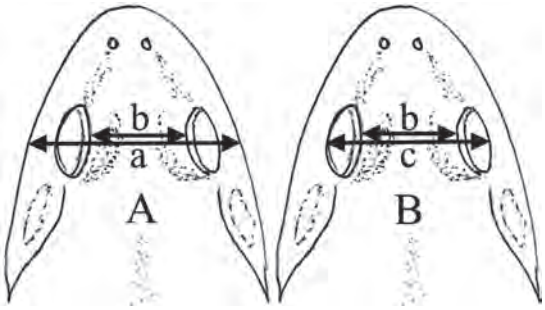

Figure 3. Head and eye biometrics. Distances *a-c* were measured along a line connecting the centres of the eyes drawn on enlarged photographs.

and eye diameter, measurements were taken for 54 individuals and subjected to t-tests applied between the six species. As an additional test, measurements were taken from photographs of frogs taken head-on, close to water level. A horizontal line was created (longer black line, Fig. 4) (using Microsoft PhotoDraw v.2) and the photographs rotated until the lower margins of the eyes were aligned with this. A straight line was then drawn through the upper and lower eyelids at their widest point in each eye. A line perpendicular to this was drawn, through the horizontal. The inclination of both eyes from this horizontal was measured using a protractor, and the angles of inclination for both eyes were averaged. The results from the two groups were compared using t-tests.

Configuration of the Dorsolateral Folds

The form and linearity of the dorsolateral folds in photographs of sixty-six water frogs and fifty-one brown frogs were compared with the examples given by Fog et al. (1997) (Fig. 2). These photographs were mostly from the author's collection supplemented with a small number from the internet.

Presence/Absence of a Temporal Mask

The presence/absence of a dark facial mask was examined either with specimens examined in the field or, for the most part, using photographs, with no conscious bias in selection. Altogether 398 water frogs, consisting of five species were examined. Approximately half of the images were from the author's collection and the rest were from the Internet.

RESULTS

Relative Distance Between the Eyes

The mean ratio of head width *a* to the distance between the eyes *b* for water frogs was 1.65 (s.d. = 0.11) and for brown frogs 1.1 (s.d. = 0.08). The assertion in Arnold et al. (1978), Arnold & Ovenden (2002) that the eyes of water frogs are 'close together' compared to those of brown frogs was strongly supported ($t = 16.9$, $p < 0.0005$).

Inclination of the Eyes

There was a significant difference in the mean

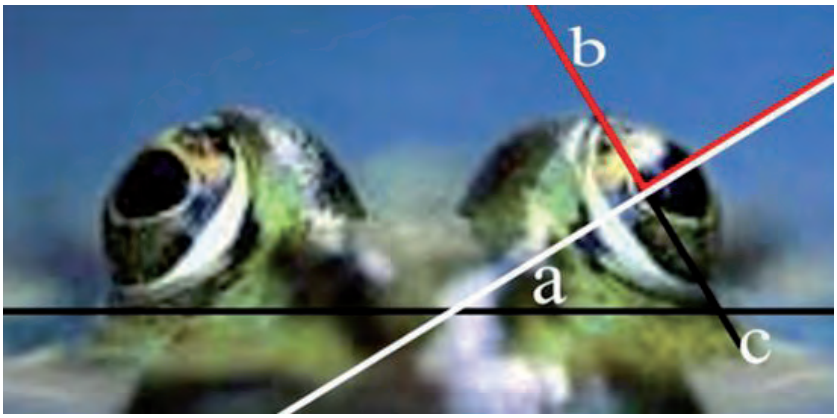

Figure 4. Measurement of angle of inclination of the eye. Using head-on photographs of frogs taken close to the water. Line *b-c* passes from the edge of the upper to lower eyelids at their widest point. The white line was drawn perpendicular to *b-c* and *a* was measured as the angle of inclination.

ratio (*c*-*b*)/*a* between water frogs and brown frogs (means = 0.27, s.d. = 0.04 and 0.13, s.d. = 0.04 respectively, t = 11.44, p < 0.0005). This equates, on average, to approximately double the proportion of the eye width visible from above in water frogs, or about one quarter of the width of the head is taken up by the eyes in water frogs and just one eight of the width in brown frogs. There were no significant differences in head width relative to body length (snout to vent) proportions between the two groups (means = 0.32, s.d. = 0.036 and 0.326, s.d. = 0.03 for water and brown frogs respectively, t = -0.55, p > 0.50). There were also no significant differences in eye diameter relative to body length (mean = 10.01, s.d. = 0.6 and 9.96, s.d. = 0.5, t = 0.58, df = 54, p > 0.55). Hence differences in the width of eye seen from above were not due to differences in the size of eyes between the two groups, but due to the angle of inclination of the eyes.

The results from the inclination measurements taken from head-on photographs also differed between the two groups (t = -10.27, P < 0.0005). The average inclination from the horizontal for brown frogs was 9° (s.d. = 5.1), while for water frogs the angle was 28° (s.d. = 3.0). The suggestion that the eyes of water frogs are more upward looking compared to those of brown frogs was, therefore, strongly supported. Neither the eye separation nor inclination results showed any overlap between the groups.

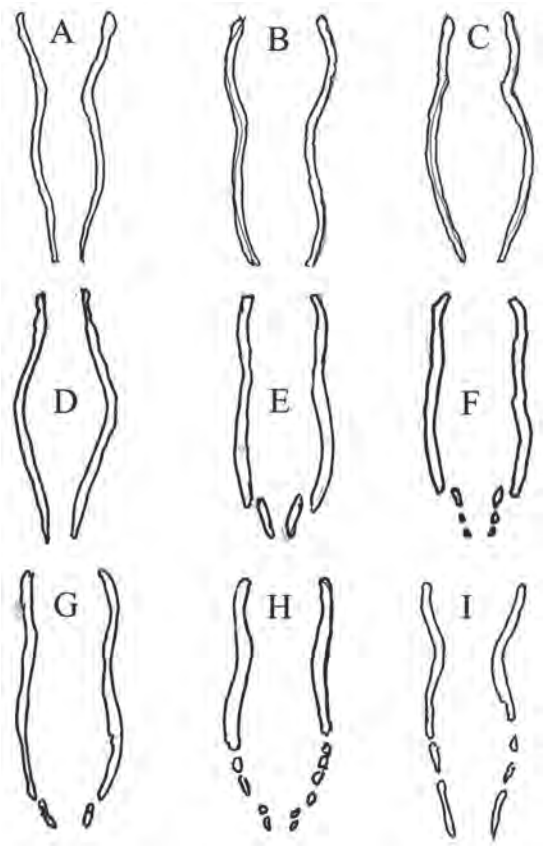

Figure 5. Dorsolateral fold pattern types across three water frog species (pool, edible and marsh frogs) and three brown frog species (common, agile and moor frogs). A–D and I were variants found only in the brown frogs, while E-H were variants found among the water frogs (Table 1.).

Configuration of the Dorsolateral Folds

The differences suggested in the dorsolateral fold patterning between the brown and water frog groups were also supported, although rather than the two forms given by Fog et al. (1997) a range of dorsolateral fold patterns was discernable. Nine variations are given in Fig. 5. There was strong agreement with the suggestion in Fog et al. (1997) that brown frogs display pattern A. Thirty brown frogs out of a total of 51 (59%) had this pattern which was not seen in water frogs. Fog et al. suggested that water frogs display the pattern shown here as E, and this was very much the case with 56 out of 66 (85%) individuals examined in agreement. No brown frogs had pattern E.

Patterns B-D were variations of the typical brown frog pattern A. F and G appeared to be variants of the more common water frog pattern E (all showed a shorter, broken posterior section with a somewhat different orientation to that of the main dorsolateral fold line). Fold pattern I (found

Fold pattern	A	B	C	D	E	F	G	H	I	Total
Brown frogs	30	9	7	2	0	0	0	0	3	51
Water frogs	0	0	0	0	56	6	2	2	0	66

Table 1. Dorsolateral fold patterns (Fig. 5) observed in brown and water frogs.

Figure 6. Examples of typical dorsolateral fold patterns. A = moor frog exhibiting typical brown frog dorsolateral fold pattern A (Fig. 5). B = pool frog (one of the last British native females, early 1990s) with a short "misaligned" posterior section (indicated by arrow) typical of water frogs.

in three brown frogs) appeared most like a broken variant of A-D (particularly A); the "chained" segments in the posterior half follow the general curving linearity of the folds (unlike the water frog pattern where the lower two or three "links" in the "chain" have a different orientation).

H (only found in two marsh frogs) was somewhat equivocal – but most resembled a broken variant of G. To help determine whether H was closer to E, F or I, it was of assistance to draw a line through the lower two "chain" segments of E-I and note that in H the lower two segments have a different linear direction to the rest of the curving form of the folds making it more consistent with the water frog pattern.

No patterns were common to both groups, however, as the sample number grew and more individuals with a chained pattern presented themselves, the dividing line became more tenuous to the point where, given more samples, this method may be best seen as a good generalisation. Photographs of frogs bearing typical dorsolateral folds are given in Fig. 6.

Presence/Absence of a Temporal Mask

The presence of a temporal stripe varied both within and between species. The results of the analysis of the 398 water frogs examined are given in Table 2. A small number of brown frogs completely lacked the temporal stripe (e.g. Fig. 7). This was more common in males than females and is particularly prevalent during the breeding season.

Further, temporal stripes were found in 33.6% of adult water frogs (4.1% of males and 63% of females) and 61% of juveniles. There is considerable variation within this trend: in northern

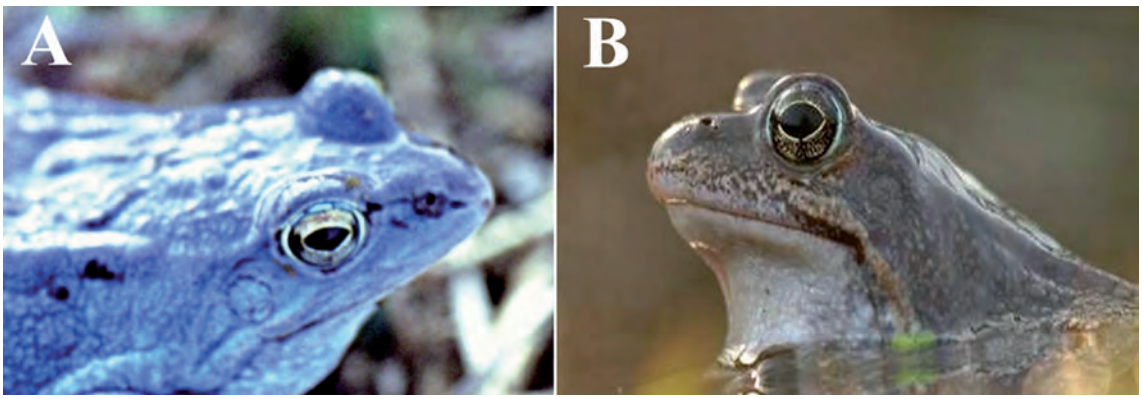

Figure 7. Brown frogs without a facial mask. A = a male moor frog from Sweden in breeding condition (Courtesy of Sven-Åke Berglind). B = breeding male common frog.

	PL Continental		PL N Clade		*P. esculentus*	
Mask	present	absent	present	absent	present	absent
Males	4	19	0	38	2	24
Females	14	6	44	0	37	19
Juveniles	15	2	29	0	17	4
% adults with mask	41.9		53.7		47.6	
% males with mask	17.4		0		7.7	
% females with mask	70		100		66.1	
% juveniles with mask	88.2		100		81	

	P. ridibundus		*P. bergeri*		*P. perezi*	
Mask	present	absent	present	absent	present	absent
Males	0	32	0	7	0	6
Females	4	41	6	0	5	8
Juveniles	0	11	3	0	0	1
% adults with mask	5.2		46.2		26.3	
% males with mask	0		0		0	
% females with mask	8.9		100		38.5	
% juveniles with mask	0		100		0	

Table 2. Proportions of water frogs with and without a facial mask. Total number of frogs = 398 (316 adult, 82 juvenile). KEY: P = *Pelophylax*, L = *lessonae*, N = northern.

clade pool frogs and *P. lessonae bergeri* 100% of the females and juveniles have a temporal mask but in *P. ridibundus* these figures are 9% and 0% respectively. Based on the sample examined here, a frequency ranking of the temporal mask is: northern clade *P. lessonae* and *P. l. bergeri* (although note the small sample number for *P. l. bergeri*) joint highest, followed by other European *P. lessonae, P.* kl. *esculentus*, *P. perezi* and *P. ridibundus*.

DISCUSSION

The results presented here, evaluating the methods for separating the northwest European brown and water frog groups, strongly validate the use of:

1) Relative distance between the eyes. The eyes of water frogs are closer together than those of brown frogs.
2) Inclination of the eyes. The eyes of water frogs are more upward looking than those of brown frogs.
3) Configuration of the dorsolateral folds.

The results show that separating the two groups on the basis of the presence/absence of a temporal mask is unreliable. Curiously, this was found to be the most frequent, long-standing and widespread method given in herpetofaunal literature.

Female and juvenile pool frogs *P. lessonae* from mainland Europe often have a temporal mask and this was also the case in the female and juvenile edible frogs examined (Table 2). The temporal mask in the northern clade pool frogs of Norway and Sweden seems to be the norm as it appears to have been, from the remaining photographs and illustrations, in the now extinct British northern clade population. Identification guidance in literature, started in the 1800s, suggesting that the presence of a temporal mask indicated a brown frog species, could have led to under-reporting of British pool frogs, which, with the exception of breeding males, had a noticeable temporal mask and, as an added complication, were also brown rather than green. Fig. 8 shows examples of brown northern clade individuals with an obvious temporal mask.

Table 2 suggests that, the result of any random sampling would show greater variation in mask frequency in mainland European *P. lessonae* populations compared to the northern clade. The frequency of mask presence in the northern clade was: males 0%, females 100%, juveniles 100%. Whereas, in continental pool frogs the frequency was, males 17%, females 70% and juveniles 88%. The facial mask characteristic is widespread in Europe but, excluding the northern clade, seems to be particularly prevalent in pool and edible frog populations east of the Alps and in northern Italy. Handbook descriptions of water frogs lacking dark temporal markings were most accurate for adult

Figure 8. Northern clade pool frogs with a temporal mask. A = juvenile male from Norfolk (John Buckley). B = juvenile from Sweden (Jim Foster).

breeding males. In the case of the marsh frog the presence of a temporal mask is unusual but does occur occasionally in females (Table 2).

It is the author's experience that as male pool frogs mature, the facial mask becomes less distinct. In breeding males in nuptial colours there is no sign of the mask at all, though it can reappear, albeit faintly, from late summer to autumn, in some individuals. The water frogs most likely to be seen are the breeding males when positioned near the water's edge and advertising their presence with loud calls. It is perhaps this fact that has led to the mistaken impression that all water frogs lack the temporal mask.

Brown frogs, too, may lose their mask in the breeding season. Approximately half of the images from the Internet depicting breeding common frogs showed the males without a mask, in some instances the females too, and this condition was even more prevalent in breeding male moor frogs. It is evident that brown and water frogs cannot be reliably separated on the criterion of the presence or absence of a temporal mask.

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